SPECIFICATION

FOR

FIBER OPTIC HYDROPHONE SYSTEM

June 1988

Prepared for
Naval Research Laboratory
Washington, D.C. 20375-5000

under
Contract No. N00014-87-C-2223

Litton
Guidance & Control Systems

5500 Canoga Avenue
Woodland Hills, California, 91367-6698

PRELIMINARY

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CDRL Sequence No. A003
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1.0 SCOPE

1.1 Scope. This specification establishes the performance requirements for a fiber optic hydrophone system designed to measure dynamic acoustic pressures at multiple locations external to the hull of U.S. Navy submarines.

2.0 APPLICABLE DOCUMENTS

2.1 Government documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of the specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered as the superceding requirements.

SPECIFICATIONS:

Military:

MIL-E-16400	Electronic, Interior Communication and Navigation Equipment, Naval Ship and Shore; General Specification for
MIL-E-17555	Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts): Packaging of
MIL-P-116	Preservation, Methods of
MIL-Q-9858A	Quality Program Requirements
MIL-S-901	Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirement for

STANDARDS:

Military

MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-109	Quality Assurance Terms and Definitions
MIL-STD-167-1	Equipment (Type I - Environmental and Type II - Internally Excited)

2.2 Nongovernment documents. The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered the superceding requirement.

STANDARDS:

Industry

ANSI-SI.20-1972	Procedures for Calibration of Underwater Electroacoustic Transducers (application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018).
ASTM-D-1141	Substitute Ocean Water, Specification for (application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

3.0 REQUIREMENTS

3.1 System description. The hydrophone system shall consist of a sensing portion (the hydrophone) which is located external to the pressure hull of the vessel. Each hydrophone is connected to an inboard electro-optics unit via fiber optic cables. The system shall contain ten identical, interchangeable hydrophones distributed throughout the hull. A single electro-optics unit is required. This unit contains one laser module and ten identical receiver modules. The laser module provides optical power to the fiber optic hydrophones. The receiver module detects the modulated optical signal from each hydrophone and converts this modulation to a voltage that is proportional to the dynamic acoustic pressure at that hydrophone location.

The remote hydrophones contain no active electronics and require no electrical power. The hydrophone is suspended in a webbed neoprene rubber structure mounted in a mounting bracket.

3.2 Hydrophone characteristics.

3.2.1 Physical requirements. The following requirements apply to the hydrophone exclusive of the webbed neoprene rubber boot.

3.2.1.1 Shape. The shape of the hydrophone shall be that of a right circular cylinder.

3.2.1.2 Length. The hydrophone length shall be less than or equal to 5.91 inches.

3.2.1.3 Diameter. The hydrophone diameter shall be less than or equal to 1.20 inches.

3.2.1.4 Mass. The mass of the hydrophone shall be less than or equal to 250 grams.

3.2.2 Acoustic performance. Unless otherwise stated, the acoustic performance requirements contained herein apply to a single hydrophone-receiver pair. The hydrophone is to include the mounting bracket or shock mounts. The hydrophone shall meet the performance specified herein under any and all combinations of the specified operating temperature (3.2.3.2) and hydrostatic pressure (3.2.3.1).

3.2.2.1 Operating frequency band. The operating frequency band of the hydrophone shall be from 64 Hz to 50 kHz.

NOTE: Paragraphs 3.2.2.2 through 3.2.2.5 shall be accomplished with hydrophone assemblies without the Mounting Bracket, NAVSEA Drawing 53711-5808790.

3.2.2.2 Receiving sensitivity. The hydrophone receiving sensitivity, as measured at the receiver output, shall fall within the shaded area shown in Figure 1, when tested in four orientations of the XY Plane (plane perpendicular to the hydrophone axis). Each orientation shall be separated by 90 degrees in angle. Total variation in the four orientations shall not be greater than 2 dB at any frequency.

3.2.2.2.1 Variation in receiving sensitivity. The receiving sensitivity, at any frequency from 64 Hz to 50 kHz shall not vary more than 3.0 dB under any combination of hydrostatic pressure within the range of 0 psig to 1000 psig, and any temperature within the range of -3 degrees Celsius to +32 degrees Celsius.

3.2.2.3 Noise spectral density. The noise spectral density as measured at the receiver output shall be within the shaded region indicated in Figure 2.

3.2.2.4 Dynamic range.

3.2.2.4.1 Dynamic range definition. The hydrophone shall be exposed to plane wave pressures in water at discrete frequencies. As the pressure amplitude is increased, the level at which any harmonic component in the receiver output is 40 dB below the fundamental is recorded. The difference between this level (in dB re 1 volt^2) and the noise spectral density at this frequency (in dB re 1 V^2/Hz) represents the dynamic range of the hydrophone.

3.2.2.4.2 Dynamic range requirement. The dynamic range as defined in section 3.2.2.4.1 shall meet or exceed the requirement as specified in Figure 3.

3.2.2.5 Receiving patterns.

3.2.2.5.1 Plane perpendicular to the hydrophone axis. Any receiving pattern perpendicular to the hydrophone axis shall have a total variation of not more than plus or minus 1.0 dB at single frequencies between 64 Hz and 50 kHz.

3.2.2.5.2 Plane containing the cylindrical axis of the hydrophone. The directivity of any receiving pattern in the plane containing the cylindrical axis of the hydrophone shall not exceed that of a 3.25 inch line hydrophone.

3.2.2.6 Acceleration response. The output of the hydrophone (as measured at the receiver output terminals) shall be within the shaded area shown in Figure 4 when the hydrophone assembly is subjected to a 0.1 g acceleration in air. Accelerations shall be applied in direction perpendicular to and parallel to the cylindrical axis of the hydrophone, keeping the cylindrical axis of the hydrophone vertical.

3.2.3 Environmental conditions. Unless otherwise specified, each hydrophone shall meet the performance requirements specified in 3.2.2 after having been subjected to any or all of the environmental conditions specified herein.

3.2.3.1 Operating hydrostatic pressure. The hydrophone shall meet the performance requirements specified in 3.2.2 when submerged in water at any hydrostatic pressure from 0 psig to 1000 psig.

3.2.3.2 Operating temperature. The hydrophone shall meet the performance requirements specified in 3.2.2 when submerged in seawater at any temperature between -3 degrees Celsius and +32 degrees Celsius.

3.2.3.3 Nonoperating temperature and atmospheric pressure. The hydrophone shall be capable of being stored throughout the temperature range of -60 degrees Celsius to +60 degrees Celsius and in a partial vacuum as low as 1.7 psia and still meet all of the performance requirements specified in 3.2.2 when the pressure and temperature are returned to the range specified in 3.2.3.1 and 3.2.3.2.

3.2.3.4 Underwater explosive shock. The hydrophone and cable, when mounted below the floating shock platform described in MIL-S-901 at a water depth of approximately eight feet, shall be capable of withstanding a series of four underwater explosive charges of 60 pounds of HBX-1 detonated at a depth of 24 feet at

horizontal standoff distances of 40, 30, 25, and 20 feet without physical damage to the hydrophone or cable. The hydrophone and cable shall meet all performance requirements specified in 3.2.2 after being subjected to the underwater shock test series.

3.2.3.5 Vibration. The hydrophone and cable, when mounted in air shall be capable of withstanding the Type I test of MIL-STD-167 without physical damage or degradation of the performance requirements specified in 3.2.2.

3.2.3.6 Cable pull. The hydrophone and cable shall be capable of withstanding a cable pull test such that a tensile force of 25 pounds in the cable will not damage the hydrophone or the cable seal.

3.2.4 Hydrophone optical requirements. The hydrophone shall be constructed of optical fiber that supports a single waveguide mode at 1310 nanometers. The following requirements apply to the hydrophone including the fiber optic cables.

3.2.4.1 Optical loss. The optical loss of the hydrophone and cable shall be measured using an incoherent source (such as a light-emitting diode) at a nominal (vacuum) wavelength of 1310 nanometers. The optical power at the output shall be no less than -8.0 dB when referred to the optical power at the input.

3.2.5 Hydrophone design and construction. [This section to be completed at a later date.]

3.3 Electro-optics unit characteristics. The following requirements apply to the electro-optics unit, exclusive of the fiber optic cable.

3.3.1 Physical requirements. The electro-optics unit shall be designed for standard nineteen-inch rack mounting. The system shall be subdivided into one laser module and ten receiver modules. The laser module shall require no more than twenty-eight square inches of panel space. Each receiver shall be interchangeable with any other and each shall require no more than fourteen square inches of panel space. The entire system, therefore, shall require no more than 178 square inches of panel space in a nineteen-inch wide rack.

3.3.2 Electrical requirements.

3.3.2.1 Power. The entire electro-optic unit shall operate from a 60 Hz, 117 volt (rms) single-phase regulated line. The unit shall require no more than 5 amperes or equivalently 585 watts.

3.3.2.2 Interface. The receiver output terminals shall be standard BNC female connectors. The outputs shall be short circuit protected and capable of driving a load of 1000 ohms resistive.

3.3.2.3 Calibration tone. Provision shall be made on the laser module for injecting via front-panel switch control a 1000 Hz calibration tone on all hydrophone channels. The frequency of this tone shall deviate no more than 1 Hz from 1000 Hz. The level of this tone shall correspond to +140 dB re 1 microPascal pressure, plus or minus 1 dB.

3.3.3 Optical requirements.

3.3.3.1 Optical outputs. Ten identical outputs shall be provided from the laser module, one per hydrophone. Coherent optical power at a wavelength of 1310 nanometers shall be available at each output. A single-mode ST-style optical connector shall be provided for each output. The optical power measured at each output shall be greater than 20.0 microwatts but shall not exceed 40.0 microwatts.

3.3.3.2 Optical inputs. An ST-style single mode fiber connector shall be provided as the hydrophone cable interface to each receiver.

3.3.4 Environmental conditions. All performance requirements defined in Section 3.2.2 shall be met when the electro-optic unit is subjected to temperatures ranging from 0 degrees Celsius to +50 degrees Celsius. All performance requirements shall be met when the electro-optic unit is subjected to relative humidity ranging from 10 percent to 95 percent, over this same range of temperature.

3.3.5 Electro-optic unit design and construction. [This section to be completed at a later date.]

3.4 Fiber optic cable. Each hydrophone is connected to the electro-optic unit via two identical fiber cables.

3.4.1 Physical requirements. The outside diameter of the fiber optic cable shall be no greater than 0.118 inch. The outside diameter of the cable shall be no less than 0.090 inch. The exterior finish shall be a nonreflective black.

3.4.2 Optical requirements. The optical loss, in decibels, at a (vacuum) wavelength of 1310 nanometers shall be less than 1.0 dB per kilometer. The fiber within the cable shall support a single waveguide mode at the nominal operating wavelength. The outside diameter of the glass cladding shall be no greater than 125 microns and no less than 123 microns.

3.4.3 Environmental conditions. All requirements specified in Section 3.2.2 shall be met when the fiber optic cable is subjected to the following environmental conditions.

3.4.3.1 Outboard pressure hull. The fiber optic cable used outside the pressure hull shall operate in seawater at hydrostatic pressures ranging from 0 psig (ambient) to 1000 psig. The cable shall operate in seawater at temperatures ranging from -3 degrees Celsius to +32 degrees Celsius. The cable shall operate over any combination of these pressures and temperatures.

3.4.3.2 Inboard pressure hull. The fiber optic cable used inside the pressure hull shall operate in air over a range of temperature from 0 degrees Celsius to +60 degrees Celsius. The cable shall operate over a relative humidity range from 10 percent to 95 percent. The cable shall operate over any combination of these temperatures and relative humidities.

3.4.3.3 Cable pull. All performance requirements stated in Section 3.2.2 shall be met when the fiber optic cable is subjected to continuous tensile loads of 50 pounds.

3.4.3.4 Minimum bend radius. All performance requirements of Section 3.2.2 shall be met when the fiber optic cable is bent over a radius of no less than 1.5 inch.

3.4.4 Fiber optic cable design and construction. [This section to be completed at a later date.]

4.0 QUALITY ASSURANCE PROVISIONS

4.1 General. The contractor shall provide and maintain an effective inspection and quality assurance program in accordance with MIL-Q-9858A. A Quality Assurance Program Plan shall be submitted to the procuring activity for approval prior to production. The program shall include, but not be limited to, fabrication, processing, assembly, inspection, test, maintenance, packaging, storage, and delivery. Any change to the approved Quality Assurance Program Plan which might affect the degree of assurance required by this specification or other applicable documents shall be submitted to the cognizant agency or approved in writing prior to implementation. Quality assurance terms and definitions shall be in accordance with MIL-STD-109.

4.1.1 Responsibility for inspection. Unless otherwise specified, the contractor is responsible for the performance of all inspection requirements specified herein. Except as otherwise specified, the supplier may utilize his own facilities or other facilities which are acceptable to the Government. The Government reserves the right to perform any of the inspections specified herein where the Government deems such inspections are necessary

to assure that the supplies and services comply with the requirements specified herein.

4.1.2 Government verification. All quality assurance operations performed by the contractor will be subject to Government verification at any time. Verification may consist of any or all of the following:

a. Surveillance of the operations to determine that practices, methods, and procedures of the approved Quality Assurance Plan are being properly applied;

b. Government production inspection to measure quality of product to be offered for acceptance;

c. Government product inspection of delivered products to assure compliance with all of the requirements specified herein, including any requirements for which detailed tests are not specified herein;

d. Failure of the contractor to promptly correct deficiencies discovered by him, or of which he is notified, shall be cause for suspension of acceptance until corrective action has been demonstrated.

4.1.3 Test plans and procedures. Inspection plans including, but not limited to, lot control procedures, test schedules, sequence of tests, accept/reject criteria and test procedures shall be prepared by the contractor prior to commencement of any inspections, including first article tests. Applicable acoustic tests shall be conducted in accordance with ANSI-S120-1972.

4.1.4 Test data recording.

4.1.4.1 Test data files. The contractor shall maintain test data files for documenting the results of each test specified herein and all other tests performed by the contractor for each hydrophone, receiver or laser module and the components thereof. These data files may utilize electronic storage devices such as magnetic disk, floppy disk, etc..

4.2 Hydrophone quality conformance inspections.

4.2.1 Production inspections. Each hydrophone offered for delivery to the Government shall successfully pass the following production inspections.

4.2.1.1 Dimensions and visual inspection. The hydrophone, cable, components, and all materials shall be subjected to dimension and visual inspections throughout the entire production process from incoming receiving inspection to final product

acceptance inspection. These inspections shall determine compliance with the requirements stated herein.

4.2.1.2 Hydrostatic pressure test. The hydrophone and its cable shall be tested for compliance with 3.2.3.1 in a pressure vessel. The sequence of four pressure cycles between 0 psig (ambient) and 1000 psig (minimum) shall be as follows:

CYCLE NO.	DURATION AT 1000 psig
1, 2, 3	30 minutes
4	2 hours

NOTE: Allow 5-10 minutes reset at ambient pressure between cycles and at end of test.

4.2.1.2.1 Hydrostatic pressure optical loss test. Obtain measurements of the optical loss of the hydrophone in accordance with 3.2.4.1.

4.2.1.3 Receiver sensitivity test. The receiver voltage sensitivity of the hydrophone shall be measured over the operating band from 64 Hz to 50 kHz with the transducer submerged in water at a temperature between -3 degrees Celsius (+27 degrees Fahrenheit) and +32 degrees Celsius (+90 degrees Fahrenheit). The measured receiver voltage sensitivity shall meet the requirements of 3.2.2.2 and Figure 1. This measurement shall be made in accordance with ANSI-S-1.20-1972.

4.2.1.4 Optical loss test. The optical loss of the hydrophone including the fiber optic cable shall be measured for compliance with 3.2.4.1.

4.2.1.5 Nondestructive cable bond test. The bond interfaces between the rubber hydrophone molding and the rubber cable jacket for each hydrophone shall be subjected to a nondestructive mold bond test. This test requires use of a tool such as a round edge probe made of rigid plastic or metal with no sharp edges or corners. A screwdriver shall not be used as the probe tool. Firmly clamp the molded hydrophone in a manner that will not damage the hydrophone and bend the cable to a minimum bend radius of 1.5 inches at the bond interface of the cable. Probe the bond interface to the cable with the tool at a point on the outside of the bend. Repeat this procedure three more times at 90 degree points around the cable. Evidence of bond separation shall be cause for rejection.

4.2.2 Production control inspection. From each lot of hydrophones which have successfully passed the production inspection tests specified herein, a group constituting the production control sample for the lot shall be selected at random in the quantity defined by MIL-STD-105D, Level II. The hydrophones in

the production control sample shall be subjected to the tests in the sequence identified in Table I under the classification of production control tests and defined by MIL-STD-105D for an Acceptable Quality Level (AQL) of 1 percent. If the production control sample hydrophones fail collectively to meet the AQL of 1 percent (where failure of any one test parameter in the sequence is classified as one defect), then the production lot shall be retested for the failed parameter(s). In addition, any and all identified defects on any single hydrophone shall be cause for rejection of that hydrophone and removal from the lot. Individual hydrophones which show such a defect and are rejected may, if practicable, be corrected and may be returned to the production lot subsequent to being resubmitted to the full sequence of production control tests, and having successfully passed the follow-on inspection. Definition of a production lot for the purpose of production control inspection shall be in accordance with 6.1.

4.2.2.1 Hydrostatic pressure test cycle five. After the hydrostatic pressure test cycle specified in 4.2.1.2 is complete, then the hydrophone shall be subjected to cycle 5 immediately following cycle 4. The duration at 1000 psig in cycle 5 shall be 24 hours. During cycle 5, the water temperature shall be varied between +25 degrees Celsius (+77 degrees Fahrenheit) and +3 degrees Celsius (+37 degrees Fahrenheit). During the 24 hour cycle, the temperature shall be maintained at each of the two extreme temperatures for at least six hours.

4.2.2.1.1 Hydrostatic pressure optical loss test. Obtain measurements of the optical loss of the hydrophone in accordance with 3.2.4.1 at 1000 psig at the end of cycle number 5 and at 0 psig after the minimum time has elapsed for reset. Failure to meet the optical loss requirements of 3.2.4.1 during the testing in the vessel or subsequent visual indication of failure after removal from the pressure vessel shall indicate failure of the hydrostatic pressure test.

4.2.2.2 Receiving patterns. The receiving patterns of the hydrophone assembly shall be tested at 1, 10, 20, and 50 kHz to determine the conformance with 3.2.2.5.1 and at 10 and 50 kHz to determine conformance with 3.2.2.5.2.

4.2.2.3 Production control soak test. Each production hydrophone and cable shall be completely immersed (except for a maximum of the last five feet of the cable end) in a shallow tank of fresh (tap) water and soaked for a minimum of five continuous days. At the end of the minimum five day soak period and with each hydrophone still immersed in the soak tank, measure and record the values for optical loss for compliance with 3.2.4.1.

4.2.2.4 Cable pull test. The hydrophone shall be tested for compliance with 3.2.3.6. The hydrophone shall be rigidly clamped at the cable entry end cap. The 25 pound pull shall be applied by winding five turns of the hydrophone cable about a three-inch cylinder and then with a yoke distributing the load equally to both ends of the three-inch cylinder, a 25 pound force (minimum) shall be applied to the yoke five times for a minimum duration of five minutes for each application of force. This test shall be conducted prior to any other quality conformance inspections.

4.2.3 First article inspections. A quantity of five hydrophones shall be fabricated for first article inspection with the tooling and procedures intended for production. The quantity of five hydrophones shall be tested in accordance with the test requirements given in Table I under the classification of first article inspection. All five hydrophones submitted for first article inspection shall be tested to the full requirements of production inspections (4.2.1) and production control inspections (4.2.2) in the sequence specified in Table I. In addition, the hydrophones fabricated for first article inspection shall be submitted to the first article inspection tests herein (4.2.3) in the quantity of hydrophones and in the sequence of tests as specified in Table I.

4.2.3.1 Nonoperating temperature and atmospheric pressure test. Nonoperating temperature performance shall be demonstrated in accordance with MIL-E-16400, except that the temperature range shall be as specified in 3.2.3.3. During this test, at the extremes of temperature, the transducer shall be subjected to a partial vacuum of at least 1.7 psia for at least four hours.

4.2.3.2 Vibration test. The hydrophone and cable shall be tested (in air) in accordance with the Type I vibration requirements of MIL-STD-167-1. The hydrophone and cable shall meet all performance requirements specified in 3.2.2 after completion of the vibration test. This test shall demonstrate compliance with 3.2.4.

4.2.3.3 First article soak test. Two first article hydrophones and cables shall be completely immersed (except for a maximum of the last five feet of the cable end) in a tank of simulated seawater (in accordance with ASTM-D-1141) and soaked for a minimum of 50 continuous days at a water temperature of 58 degrees plus or minus 2 degrees Celsius. At the end of the minimum 50 day soak period, with each hydrophone still immersed in the simulated seawater, allow the water temperature to come to 20 degrees Celsius plus or minus 3 degrees Celsius and measure for compliance with the optical loss requirement specified in 3.2.4.1.

4.2.3.4 Acceleration response. The acceleration response of the hydrophone assembly shall be tested to determine conformance with 3.2.2.6.

4.2.3.5 Operating temperature and pressure test. All first article hydrophones shall be electroacoustically tested as a function of operating pressure and temperature to determine compliance with the requirements of 3.2.2.2.1 and 3.2.2.5 This test shall be performed at NWSC Crane, IN. The receiving voltage sensitivity shall be measured over the operating frequency of 64 Hz to 50 kHz at the following combinations of hydrostatic pressure and water temperatures:

a. 20 psig at +3 degrees Celsius, +22 degrees Celsius, and +32 degrees Celsius.

b. 300 psig at +3 degrees Celsius and +22 degrees Celsius.

c. 600 psig at +3 degrees Celsius and +22 degrees Celsius.

d. 1000 psig at +3 degrees Celsius.

4.2.3.6 Underwater explosive shock test. Three hydrophones shall be subjected to the underwater explosive shock test sequence to demonstrate conformance with the requirements of 3.2.3.4. The hydrophones shall be mounted to a Government-furnished fixture which simulates shipboard mounting conditions. The test fixture is attached to the bottom of the floating shock platform such that the hydrophone will be at a water depth of approximately eight feet. Four separate explosive charges of 60 pounds of HBX-1 shall be detonated at a water depth of 24 feet. The horizontal standoff distances from the test fixture for the four-shot sequence (in order) shall be 40, 30, 25, and 20 feet. Between detonations, the shock platform shall be lifted out of the water and the hydrophones and cables shall be visually inspected and optically checked. In this shock environment, the hydrophone shall not be physically damaged and shall meet all the requirements specified herein.

4.2.3.7 Post-shock operating temperature and pressure test. The hydrophones which are subjected to the underwater explosive shock test (4.2.3.6) shall be electroacoustically retested at NWSC Crane, IN. However, the receiving voltage sensitivity shall be measured only at +3 degrees Celsius at 20 psig, 300 psig, and 1000 psig. The measured receiving voltage sensitivity shall meet the requirements of 3.2.2.2.1 and 3.2.2.5.

4.2.3.8 First article final inspection. Upon completion of the first article test sequence as required by Table I, first article hydrophones shall be inspected for damage, water leakage, deterioration and compliance with all requirements specified herein. The procuring activity shall be notified prior to the post test inspection in sufficient time so that the Government representatives may witness the inspections.

One or more first article units shall be subjected to destructive inspection by NWSC Crane, IN. The inspections may include visual inspection, X-ray inspection, cutting or sawing hydrophones and cable in sections and removal of rubber cover.

4.3 Electro-optic unit quality conformance inspections. [This section to be completed at a later date.]

4.4 Fiber optic cable quality conformance inspections. [This section to be completed at a later date.]

5.0 PREPARATION FOR DELIVERY

5.1 Preservation and packaging. The hydrophones shall be preserved, packaged, and marked in accordance with Level A requirements of MIL-E-17555.

6.0 DEFINITIONS

6.1 Production lot. A production lot shall consist of hydrophones produced by one manufacturer under essentially the same conditions, using identical materials, manufacturing processes and controls. After initial qualification, any change in the materials, manufacturing processes or controls shall constitute a change of the production lot and may require requalification at the suppliers expense or may result in rejection of the hydrophones. Any interruption of production in excess of six months may terminate that production lot.

TABLE I. TEST SEQUENCE REQUIREMENT CHART

ABBREVIATED TEST TITLE	PARAGRAPH	FIRST ARTICLE TEST SAMPLE ORDER	SIZE	PRODUCTION TEST ORDER	PRODUCTION CONTROL TEST ORDER	REQUIREMENT
Dimensional and Visual	4.2.1.1	(THROUGHOUT INCOMING TO FINAL INSPECTION)				3.2
Hydrostatic	4.2.1.2	2	5	2	3	3.2.3.1
Receive Voltage Sensitivity	4.2.1.3	4	5	3	5	3.2.2.2
Optical Loss Test	4.2.1.4	5	5	4	8	3.2.4.1
Cable Nondestructive Bond	4.2.1.5	6	5	1	2	---
Cycle #5 Hydrostatic	4.2.2.1	3	5	N/A	4	3.2.3.1
Receiving Pattern	4.2.2.2	8	5	N/A	6	3.2.2.5
Production Control Soak	4.2.2.3	7	5	N/A	7	3.2.4.1
Cable Pull	4.2.2.4	1	5	N/A	1	3.2.3.6
Nonoperating Temp and Pressure	4.2.3.1	9	5	N/A	N/A	3.2.3.3
Vibration	4.2.3.2	10	5	N/A	N/A	3.2.3.5
First Article Soak	4.2.3.3	11	2	N/A	N/A	3.2.4.1
Acceleration Response	4.2.3.4	12	5	N/A	N/A	3.2.2.6
Operating Temp and Pressure	4.2.3.5	13	5	N/A	N/A	3.2.2.5 3.2.2.2.1

TABLE I. TEST SEQUENCE REQUIREMENT CHART (CONTINUED)

ABBREVIATED TEST TITLE	PARAGRAPH	FIRST ARTICLE TEST SAMPLE ORDER	SIZE	PRODUCTION TEST ORDER	PRODUCTION CONTROL TEST ORDER	REQUIREMENT
Explosive Shock	4.2.3.6	14	3	N/A	N/A	3.2.3.4
Post Shock Oper. Temp and Press	4.2.3.7	15	3	N/A	N/A	3.2.2.2.1 3.2.2.5
First Article Final Inspection	4.2.3.8	16	5	N/A	N/A	3.0

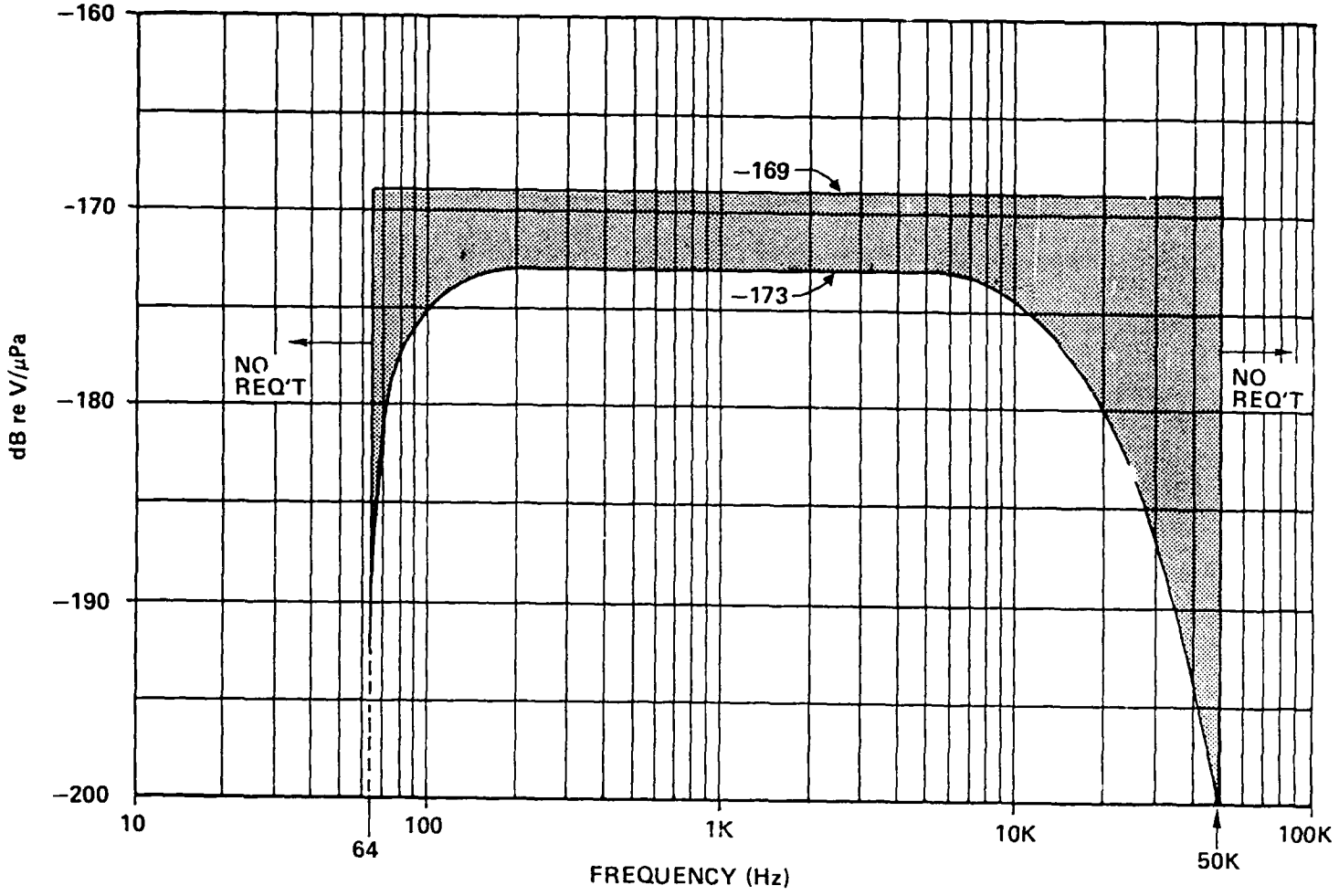

Figure 1. Receiving Sensitivity Requirement

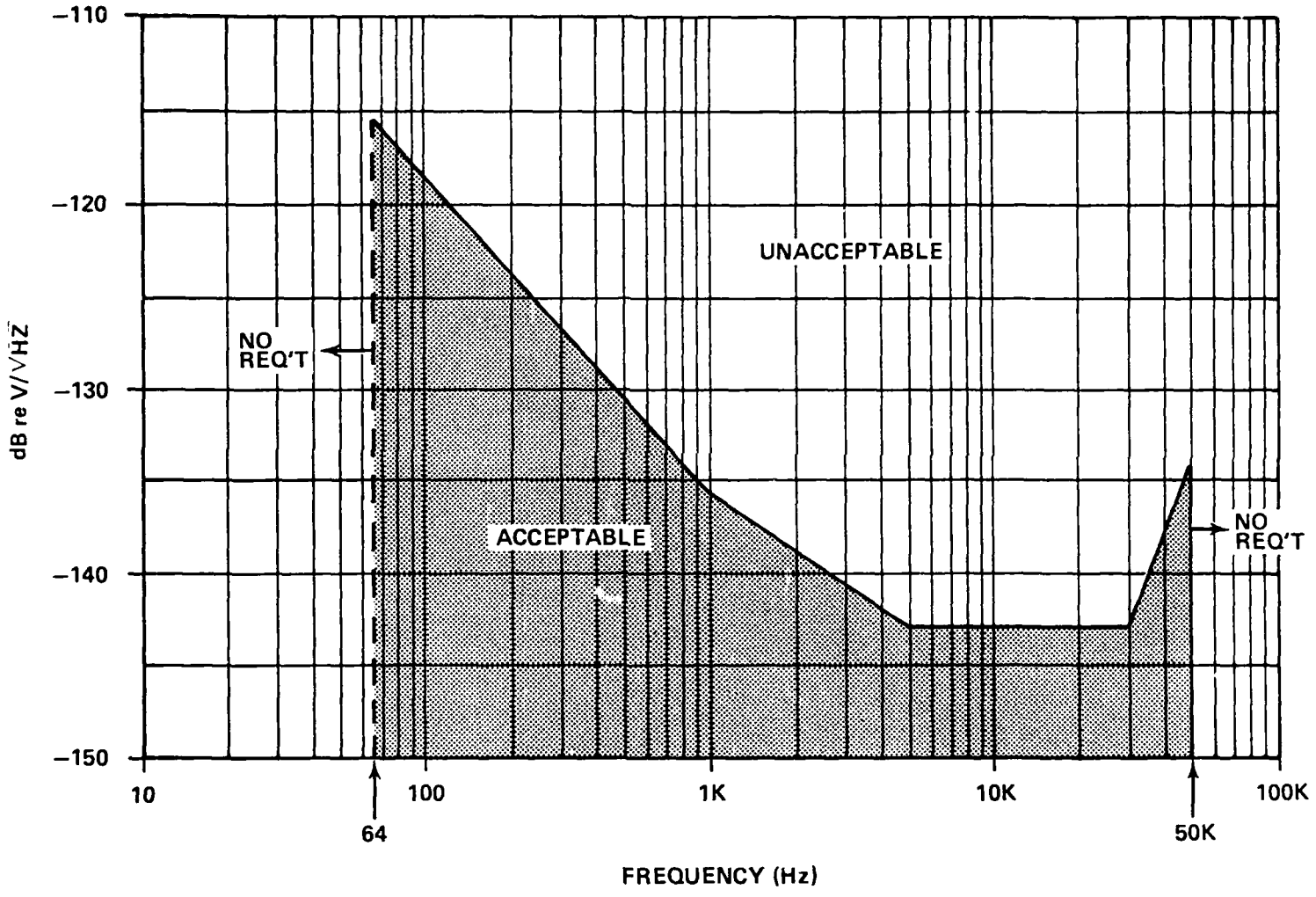

Figure 2. Noise Spectral Density Requirement

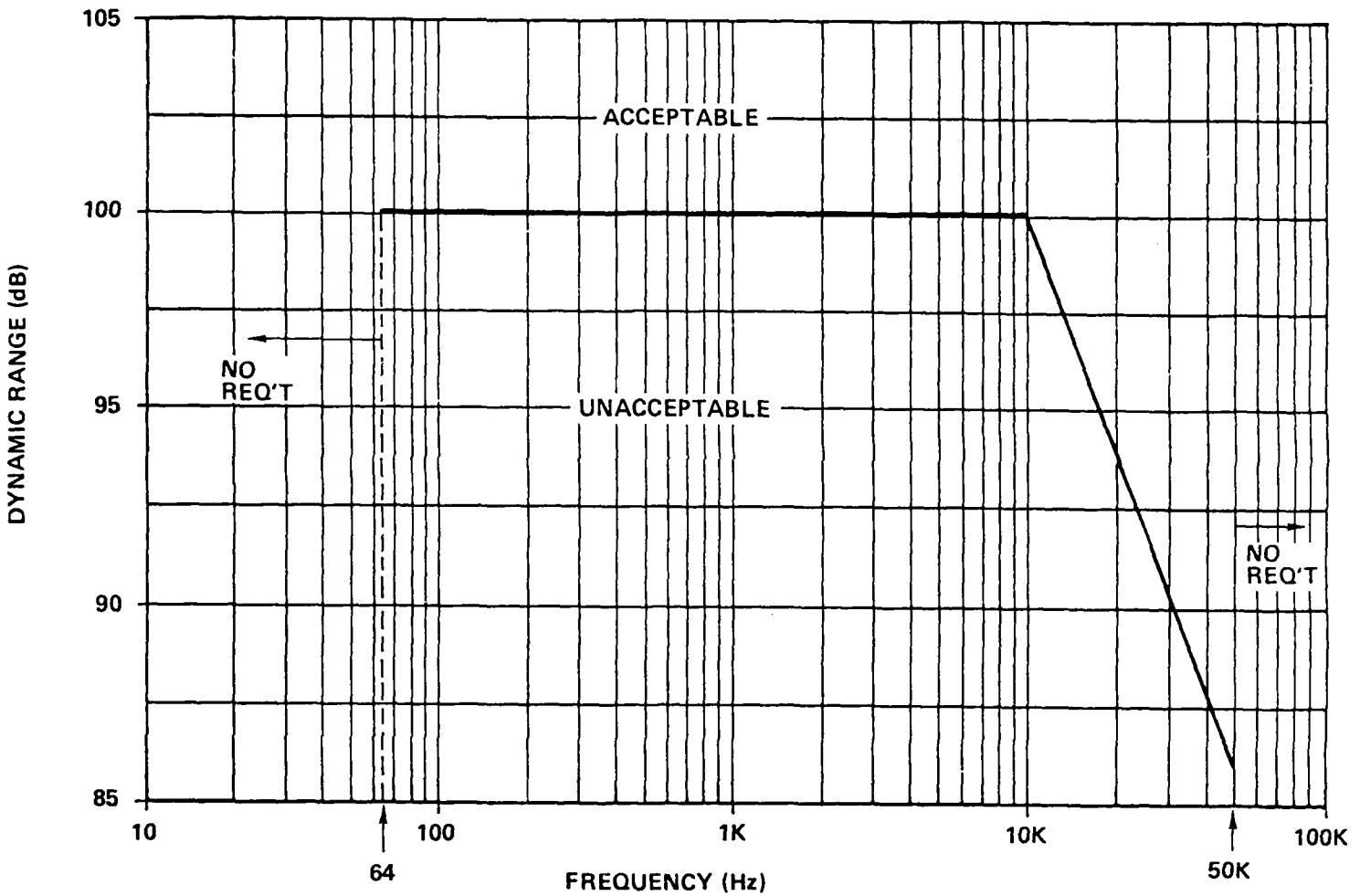

Figure 3. Dynamic Range Requirement

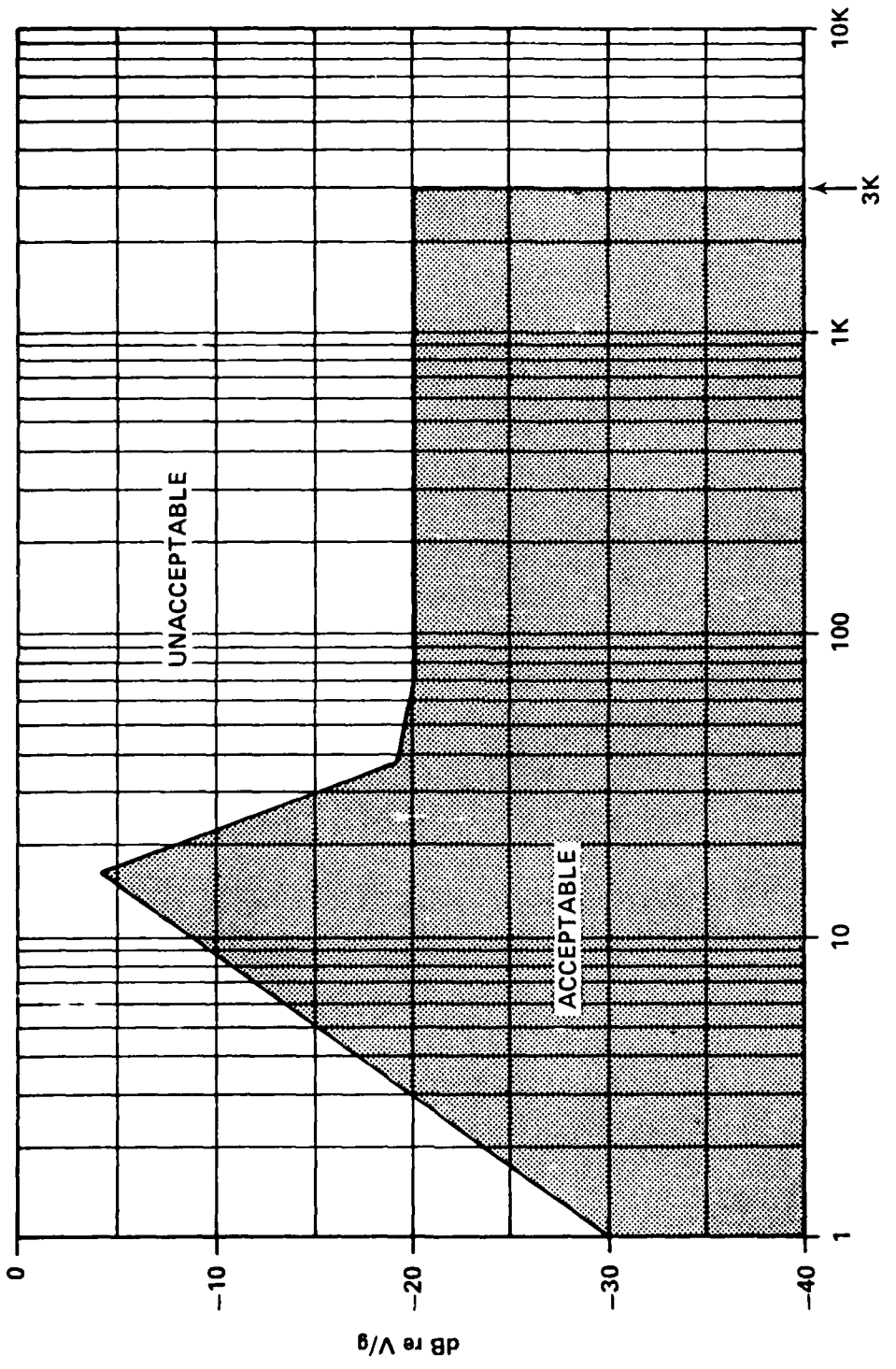

Figure 4. Acceleration Sensitivity Requirement

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